NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION PIPELINE
CORRUGATED, RIBBED OR PROFILE WALL THERMOPLASTIC PIPE

(ft)

CODE 430 JJ (INTERIM)

DEFINITION

A pipeline and appurtenances installed to convey water for storage or application through an irrigation water system.

PURPOSE

Deliver or convey water from a source of supply to points of application or storage.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to water conveyance and distribution pipelines where water is transported in a closed conduit from a source of supply to a point of use. Pipelines shall be planned and located to serve as an integral part of the water storage, distribution, or conveyance systems. They shall be designed to facilitate the conservation, use, and management of soil and water resources.

The pipeline may be installed above (with exposure considerations) or below ground to:

- facilitate moving of water between two points;
- prevent erosion or damage to the land;
- prevent degradation or loss of water quality;
- conserve water through proper management and distribution of irrigation water;
- mitigate water rights.

CRITERIA

General Criteria Applicable to all Irrigation Pipelines

The water supply, quality, and rate of irrigation delivery for the area served by the pipeline shall be sufficient to make irrigation practical and economically feasible for the crops to be grown and the irrigation water application methods to be used.

Pipelines shall be placed only in soils and environmental conditions suitable for the material type being selected.

This practice shall conform to all federal, state, and local laws and regulations. Laws and regulations of particular concern include those involving water rights, land use, pollution control, property easements, wetlands, preservation of cultural resources, and endangered species.

Capacity. Capacity shall be sufficient to provide an adequate irrigation stream for the irrigation application methods or planned storage .

Design capacity of the pipeline conveyance or distribution system shall be based on one of the following:

1. Adequate to meet the moisture demands of all crops to be irrigated in the design area.
2. Sufficient to meet the requirements of selected irrigation events during critical

crop growth periods when less than full irrigation is planned.

3. For special-purpose irrigation systems, sufficient to apply a stated amount of water to the design area in a specified operating period.

4. Sufficient to meet the requirements for efficient application with the distribution system.

In computing the above capacity requirements, allowance must be made for reasonable water losses during application or use.

Working pressure and velocity.

The following definitions shall apply to pressure and velocity criteria:

- Working pressure - the maximum anticipated sustained operating pressure at the design flow for the system.
- Surge pressure - the maximum pressure increase greater than working pressure (sometimes called water hammer) that is anticipated in the system as a result of change in velocity in the water. Some causes of surge include the opening and closing (full or partial) of valves; starting and stopping of pumps; changes in reservoir elevation; liquid column separation; and entrapped air.
- Total system pressure – the sum of working pressure plus surge pressure.
- Static pressure - the internal pressure when no flow is occurring in the pipe.
- Collapse pressure (critical buckling pressure) – the negative pressure at which the pipe collapses caused by water column separation from valve closure, sudden air evacuation, surge pressures, or other causes.

When operating at design capacity, the full-pipe flow velocity in the pipeline should not exceed 5 feet per second in pipelines with valves or some other flow control appurtenance placed within the pipeline or at the downstream end. As a safety factor against surge, the working pressure at any point should not exceed 72 percent of the pressure rating of the pipe. If either of these limits is exceeded, special design consideration must be given to the flow conditions and measures must be taken to adequately protect the pipeline against these pressures.

If no appurtenances or valves are located within the pipeline, the working pressure should not exceed the maximum allowable pressure of the pipe at any point.

The pipeline shall also be designed to ensure static pressure at any point does not exceed the maximum allowable pressure of the pipe. The static or working pressure of pipelines open to the atmosphere shall include freeboard.

The maximum allowable pressure of the pipe shall be 10.8 pounds per square inch (psi) or 25 feet.

Friction and other losses. For design purpose, pipe friction head losses shall be computed using Mannings, Hazen-Williams or Darcy-Weisbach equations. The appropriate equation to use shall be determined for the given flow condition and the pipe material selected.

Use of these equations and selection of appropriate coefficients shall be in accordance with procedures described in the NEH Part 650, Engineering Field Handbook, or equivalent publication(s).

Other head losses (also called "minor losses") from change in velocity and direction of flow due to inlet type, valves, bends, enlargements or contractions can be significant and should be considered. Procedures to compute or estimate these losses shall be as described in the NEH Part 650, Engineering Field Handbook, or equivalent publication.

Thermal Effects. Thermal effects must be properly factored into system design. Pressure rating for the pipe is normally based on pipe temperature of 73.4 degrees Fahrenheit (F). When operating temperature is higher the effective pressure rating of the pipe shall be reduced.

Values and procedures for pressure rating reduction shall follow information described in the NEH Part 650, Engineering Field Handbook or equivalent publication.

Inlets. Inlets shall be of adequate size for the type of entrance condition to ensure that the design flow capacity allows entry into the pipeline without excessive head losses.

Provision shall be made to prevent the inflow of trash or other materials into the pipeline if these materials would be detrimental to the pipe capacity or performance of the irrigation application system.

For gravity flow inlets with square edge or gated orifices, the nappe created by inflow at the orifice entrance should be vented.

Water control structures, stands, or z-pipes (see definition of z-pipes or doglegs under stands) are all acceptable inlet devices. Water control structures are commonly used for gravity flow pipelines, but do not account for removal of entrained air. Therefore, pipelines using these inlets must also meet requirements under vents.

Stands open to the atmosphere. Stands may be used wherever water enters the pipeline system to avoid entrapment of air and collapse caused by negative pressures (vacuum relief), and to prevent total system pressures from exceeding the maximum allowable working pressure of the pipe. Open stands may also be required at other locations in low-head systems to perform the above functions. Stands shall be constructed of steel pipe or other approved material on a base that is adequate to support the stand and prevent movement or undue stress on the pipeline. Open stands shall be designed to meet or exceed the following criteria:

1. Each stand shall allow at least 1 foot of freeboard above design working head. The stand height above the centerline of the pipeline shall be such that neither the static head nor the design working head plus freeboard exceeds the allowable working pressure of the pipe.
2. The top of each stand shall extend at least 4 feet above the ground surface except for surface gravity inlets, where visibility is not a concern or where there is a potential for damage from animals.
3. If the water velocity in the inlet (from the pump or other water source) equals or exceeds three times the velocity in the outlet pipeline, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.
4. The downward water velocity in stands shall not exceed 2 feet per second. The inside diameter of the stand shall not be less than the inside diameter of the pipeline. This downward velocity criterion applies only to stands having vertical offset inlets and outlets.
5. The cross-sectional area of stands may be reduced above a point 1 foot above the top of the upper inlet or outlet pipe, but the reduced cross section shall not be such that it would produce an average velocity of more than 10 feet per second.
6. Vibration-control measures, such as special couplers or flexible pipe, shall be provided as needed to ensure that vibration from pump discharge pipes is not transmitted to stands.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 inches and shall be constructed so that the bottom is at least 24 inches below the invert of the pipeline outlet. The downward velocity of the waterflow in a sand trap shall not exceed 0.25 feet per second.

Gate stands shall be of sufficient dimension to accommodate the gate or gates and shall be large enough to make the gates accessible for repair.

Float valve stands shall be large enough to provide accessibility for maintenance and to dampen surge.

Stands closed to the atmosphere. If pressure-relief valves (PRV) and air-release and vacuum-relief valves (AVR) are used instead of open stands, all requirements under “Stands Open to the Atmosphere” shall apply except as modified below.

The inside diameter of the closed stand shall be equal to or greater than that of the pipeline to at least 1 foot above the top of the uppermost inlet or outlet pipe. To facilitate attaching the PRV valve and the AVR valve, the stand may be capped at this point; or, if additional height is required, may be extended to the desired elevation by using the same inside diameter or a reduced cross section.

The PRV and AVR valves shall be installed on stands with nominal size pipe required to fit the valves' threaded inlets.

If no vertical offset is required between the pump discharge pipe and the outlet pipeline and the discharge pipe is directed downward with a sharp bend below ground, the stand shall extend to at least 1 foot above the highest part of the pump discharge pipe.

An acceptable alternative design for stands requiring no vertical inlet offset (when inlet velocity is less than three times that of the discharging pipeline) shall be to:

1. Construct a z-pipe section to the pump discharge pipe with the same nominal diameter as that of the pipeline.

   A z-pipe (also called a "dogleg") is a pipe with two adjacent abrupt bends. The first directs the pipe downward on a 45-degree angle or less. The second bend is opposite in direction and changes the steep sloping pipe to a (near) horizontal slope. The opposite configuration is used when z-pipes are used as outlets.

2. Install the PRV and/or AVR valves on the top of the upper horizontal section of the z-pipe.

Check valves. A check valve shall be installed between the pump discharge and the pipeline to prevent back-flow damage to some types of pumps or if necessary to prevent back-flow from draining the line. Check valves can cause extreme internal pressures, due to water hammer, if they close too fast as flow reversal occurs. "Non slam" type check valves or solenoid operated valves that are essentially closed before flow reversal occurs may be required.

Surge Tanks and Air Chambers.. If surge tanks and/or air chambers are required for control of hydraulic transients or water column separation they shall have adequate size to ensure the water volume needs of the pipeline are met without the tank/chamber being emptied and that the required flow into the pipeline for the calculated pressure drop is met.

Pressure-relief valves (PRV). A pressure-relief valve (PRV) shall be installed between the pump discharge and the pipeline if excessive pressure can build up when all valves are closed. If needed to protect the pipeline against pressure-reducing valve malfunction or failure, PRV valves shall be installed downstream of pressure-reducing valves in pressurized pipelines. PRV valves normally do not operate fast enough to protect the pipeline from transient pressures caused by water hammer.

Manufacturers of PRV valves marketed for use under this standard shall provide capacity tables that give the discharge capacities of the valves at the maximum permissible pressure and differential pressure settings. These tables shall be based on performance tests and shall be the basis for design of pressure setting and of acceptance of these valves.

PRV valves shall be set to open at a pressure as low as practical, but no greater than 5 pounds per square inch (psi) above the pressure rating or maximum allowable pressure of the pipe. The valves shall have sufficient flow capacity to reduce the excessive pressures in the pipeline.

The pressure at which the valves start to open shall be marked on each pressure-relief valve. Adjustable PRV shall be sealed or otherwise altered to prevent changing the adjustment from that marked on the valve.

Air-release valves. Five types of air vents/valves commonly used on irrigation pipelines are continuous acting air-release valves (CAV), vacuum-relief valves (VR), air-release and vacuum-relief valves (AVR), combination air valves (COMB), and open vents. Open vents are described in the next section.

If accumulation of air during operation may occur CAV shall be used to release air from the filled pipeline while under pressure.

VR valves shall be used for relief of vacuum pressures (i.e., negative pressures) due to sudden gate or valve closure, pump shutoff, or drainage of the pipeline.

AVR valves may be used for the same requirements described for VR valves. These valves shall also be used to release air from the pipeline on filling prior to the pipe being pressurized. They shall be used to alleviate flow restrictions, air locks, and water surging due to the presence of air within pipelines.

COMB valves have the combined function of all three valves (CAV, VR, and AVR) in one body. COMB valves may be used for any of the conditions in which a CAV, VR, or AVR is required.

If needed to provide positive means for air escape during filling and air entry while emptying, an AVR, VR, or COMB valve should be installed at summits, upstream and downstream of all in line valves as needed, at the entrance, and at the end(s) of the pipelines. Such valves generally are needed at these locations if the line is truly closed to the atmosphere. However, they may not be needed if other features of the pipe system, such as permanently located sprinkler nozzles or other unclosed service outlets, adequately vent the particular location during filling and emptying operations. The use of these system features must be analyzed for airflow rate and the proper use of such features described in the Operation and Maintenance (O&M) plan.

In addition to the locations described above, an AVR or COMB valve shall be located at changes in grade, in downward direction of flow, in excess of 10 degrees to ensure adequate air release during filling. On long pipelines, additional AVR or COMB valves may be required to adequately vent the pipe during filling.

For air release, the AVR or COMB valve shall be sized to exhaust air from the pipeline at the rate needed to prevent operating problems with the pipeline while maintaining proper operation of the valve.

For vacuum relief, the AVR, VR, or COMB valves shall be sized for air entry into the pipeline ensuring that the pipeline does not collapse due to vacuum created during drainage of the pipeline.

If the required vacuum relief orifice diameter is significantly larger than the required air release orifice diameter, separate valves may be required to help eliminate excessive water hammer caused when the air is released too fast from the pipeline.

CAV or COMB valves shall be used as needed to permit air to escape from the pipeline while the line is at working pressure. Small orifices of these types shall be sized according to the working pressure and venting requirements recommended by the valve manufacturer.

The location of the CAV or COMB valves shall be sufficient distance downstream from the introduction of air into the system (under pressure conditions) to allow the air to be collected at the top of the pipe. Under some circumstances (e.g., pumped system with low pressure or velocity) consideration should be given to installing vent chambers for CAV or COMB valves. The vent chamber should be constructed according to the requirements under criteria 2 in the “Vents” section of this standard.

Manufacturers of air valves marketed for use under this standard shall provide dimensional data or a capacity table based on performance tests, which shall be the basis for selection and acceptance of these valves.

Vents. Venting must be designed into systems open to the atmosphere to provide for the removal and entry of air and protection from surge. The following criteria shall apply:

1. Vents shall have a minimum freeboard of 1 foot above the hydraulic gradeline at design capacity. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum allowable working pressure of the pipe.
2. A vent chamber shall be constructed to intercept and/or capture air within the pipeline. The chamber shall intercept the circumference arc of 75 degrees at the top of the pipe (i.e., a vent chamber diameter

of 2/3 the diameter of the pipeline). The chamber shall extend vertically at least one pipeline diameter up from the centerline of the pipeline. Above this elevation, the vent chamber may be reduced to minimum 2 inches in diameter.

When an AVR or COMB valve is used instead of a vent, the above requirements shall apply except that the reduced section shall be sized to meet the nominal pipe size required to fit the valve's threaded inlet. An acceptable alternative is to install the valve(s) in the side of a service outlet, provided that the service outlet riser is properly located and adequately sized. If both AVR and PRV valves are required at the location, the 10 foot per second velocity criteria given under "Stands Open to the Atmosphere" shall apply to the reduced section.

3. A vent shall be located at the downstream end of laterals, at summits in the line, and at points where the grade changes more than 10 degrees in a downward direction of flow.

Outlets. Appurtenances to deliver water from the pipe system to the field, ditch, reservoir, storage, or surface pipe system shall be known as outlets. Outlets shall have adequate capacity to deliver the required flow to:

1. The hydraulic gradeline of a pipe or ditch.
2. A point at least 6 inches above the field surface.
3. The design surface elevation in a reservoir.
4. An individual sprinkler, lateral line, hydrant, or other device at the required operating pressure.

Outlets shall be designed to minimize erosion, physical damage, or deterioration caused by exposure.

Pipeline Siphons and Pump Suction Lines (Pipelines Subject to Negative Internal Pressure). Pipelines such as siphons and pump suction lines that are subject to negative internal pressures shall be adequately designed to withstand the negative pressures without collapsing. The design should consider the effects of external loading and the deformation of the pipe..

Filling. Filling requirements shall be as specified in the Operation and Maintenance (O&M) section of this standard. If special appurtenances, provisions or requirements are needed for filling the pipeline they shall be included in the design or noted in the O&M plan.

Flushing. If the sediment load in the water is significant, the pipeline shall have adequate velocity to ensure that sediment is moved through and/or flushed out of the pipeline.

If provisions are needed for flushing sediment or other foreign material, a suitable valve shall be installed at the distant end of the pipeline.

Drainage. Provisions shall be made for completely draining the pipeline when:

- Freezing temperatures are a hazard.
- Drainage is recommended by the pipe manufacturer.
- Drainage of the line is otherwise specified.

If provisions for drainage are required, drainage outlets shall be located at all low points in the line. These outlets may drain into dry wells, drain fields, or to points of lower elevation. If free drainage cannot be provided by gravity, provisions shall be made for emptying the line by pumping or by other means.

Thrust control for below ground pipe. Abrupt changes in pipeline grade, horizontal alignment, tees, or reduction in pipe size, normally require an anchor or thrust blocks to absorb pipeline axial thrust. Thrust control may also be needed at the end of the pipeline and at in-line control valves.

Thrust blocks and anchors must be of sufficient size, based on passive soil pressure, to withstand the forces tending to move the pipe. Forces include momentum, pressure, expansion, and contraction.

The pipe manufacturer's recommendations for thrust control shall be followed. In absence of manufacturer's data, thrust block design shall meet the requirements described in the NEH Part 650, Engineering Field Handbook.

Thrust control and restraints for aboveground pipe. For aboveground pipelines with welded joints, anchor blocks and expansion joints shall be installed at spacings that limit pipe movement due to expansion or contraction to a maximum of 40 percent of the sleeve length of the expansion coupling to be used. The maximum pipe length between expansion joints shall be 500 feet.

Aboveground pipelines with rubber gasket-type joints shall have movement restrained by steel holddown straps at pipe supports or by uniformly spaced anchor blocks.

Thrust blocks shall be required on aboveground pipelines at all points of abrupt changes in grade, horizontal alignment, or reduction in size. The blocks shall be of sufficient size to withstand momentum, pressure, and expansion and contraction forces that might cause pipe movement.

Pipe supports. Irrigation pipelines permanently placed above ground should be supported, where needed, to prevent movement due to external and internal forces. These supports may include, but are not limited to, concrete, steel, or timber saddles shaped to support the pipe.

For suspended pipelines, support spacing shall ensure that neither the maximum beam stress in the pipe span nor the maximum stress at the support exceed the allowable stress values and vertical deflection (sag) is within acceptable limits.

Joints and connections. All connections shall be designed and constructed to withstand the pipeline working pressure without leakage and leave the inside of the pipeline free of any obstruction that would reduce capacity.

Permissible joint deflection shall be obtained from the manufacturer for the joint type and pipe material used.

For sloping steel pipe, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks.

For welded pipe joints, expansion joints shall be installed, as needed, to limit pipeline stresses to the allowable values.

For suspended pipelines, joints shall be designed for pipe loading including the water in the pipe, wind, ice, and the effects of thermal expansion and contraction.

Joints and connections should be of similar materials whenever possible. If dissimilar materials are used, the joints or connections shall be protected against galvanic corrosion.

As a minimum, the joint shall be watertight as specified in the requirement under ASTM D3212.

Depth of Cover. Buried pipe shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by traffic crossings, farming operations, freezing temperatures, or soil cracking, as applicable.

Pipelines shall have sufficient strength to withstand all external loads on the pipe for the given installation conditions. Appropriate live loads shall be used for the anticipated traffic conditions.

Pipe Loading and Deflection. The pipeline and backfill system shall be designed to support the anticipated soil and vehicular loads. The pipe shall have adequate strength to withstand the flexural and buckling stresses produced by these loads without causing excessive short- and long-term deflection.

Materials. All materials described in this standard shall meet or exceed the minimum installation and material requirements, including referenced American Society for Testing and Materials (ASTM), American water Works Association (AWWA) and other standards, as listed in the NEH Part 650, Engineering Field Handbook.

CONSIDERATIONS

For pump systems with velocities over 5 feet per second, an economic analysis should be considered to determine whether an increase in pipe diameter with associated costs will offset decreased pumping costs due to reductions in energy consumption.

If irrigation application methods (e.g., trickle irrigation) require limited working pressures, pressure relief valves should be considered to ensure that the pressure created in the pipeline does not exceed the allowable pressure for the system components.

Chemigation valves (i.e., double seated check values with air relief valve and low pressure drain) should be used on all pipelines in which fertilizer, pesticides, acids, or other chemicals are added to the water supply and where drainage may contaminate the mainline, water supply, or groundwater.

Where pipelines are to be drained, consideration should be given to safe disposal of drained water.

For pumped pipelines, consider if detrimental water column separation could occur in the pipeline following power failure or power shutoff . If the impacts are significant consider increasing the strength of the pipeline or use of a surge tank(s) and/or air chamber(s) to maintain the water column integrity.

Consideration should be given to the direction of water leaving an air valve or pressure relief valve. The flow should be directed away from electrical equipment and hook-ups.

Designs should consider safety elements when installations are effected by utilities.

PLANS AND SPECIFICATIONS

Plans and specifications for construction of irrigation pipelines shall be prepared in accordance with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An operation and maintenance (O&M) plan shall be developed for each pipeline system installed. The plan should document needed actions to ensure that practices perform adequately throughout their expected life.

O&M requirements shall be included as an identifiable part of the design. Depending on the scope of the project, this may be accomplished by brief statements in the plans and specifications, the conservation plan narrative, or as a separate O&M plan.

Other aspects of O&M, such as drainage procedures, defining crossing location, valve(s) operation to prevent pipe or appurtenant damage, other appurtenance or pipe maintenance, and recommended operating procedures, should be described as needed within the O&M plan.

Filling. Filling velocities greater than 1.0 fps in a closed to atmosphere pipe system (i.e., all outlets closed) requires special evaluation and provisions to remove entrapped air and prevent water hammer surges.

Developing filling schedules with allowable filling rate at the various phases of the filling process may be required. Appurtenances, such as a flow meter, weir, etc., or other means (e.g., number of turns of a gate valve) should be used to determine the rate of flow into the pipeline. This information if developed, should be provided to the operator and be incorporated into the O&M plan.

If filling at a slow flow rate is not possible, the system shall be open to the atmosphere (outlets open) prior to pressurizing. The system valve(s) to the irrigation application device (gated pipe, wheel line, pivot, etc.) should be opened to release entrapped air and minimize water hammer in the system. This operation procedure shall be included within the O&M plan. The system shall also be designed for air removal and transient surge pressures that may develop at the higher filling rate.